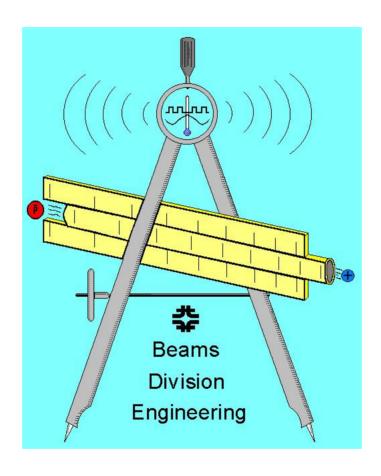
Accelerator Complex Reliability



Outline

- You will hear
 - > Status of projects since October DOE Review.
 - > New issues since then.
 - > How we do our maintenance and planning.
 - > Examples of tracking system performance.
- I believe you will find we have a well established system and place a high emphasis on reliability and performance.

Information From the DOE Review

- As of 10/01/02 the largest accumulated downtime was from:
- Tevatron Accelerator Systems- TQUEN
 - > Magnet Quenches (all causes)
 - WARNING be careful of what the name implies! Some failures in this category were caused by the protection systems i.e. QPM or VFC that caused the magnets to quench.

Kicker Pre-fires

- Case of "...if a little is good, a lot is better!"
 - Reservoir pressures were raised to make kicker firing easier on the tubes. It also made kicker firing <u>Easier!</u> Put the tube very near the threshold of pre-firing so anything could (and did) set them off.
- We backed down in March and have not had a prefire since then. It is still too soon to tell what the longer term will bring.

A Case Study

- Last year VFC's were the cause of 10 lost stores.
 - 7 failures were in Low Beta houses where there are 45 cards installed.
 - 3 failures were in the rest of the machine where there are 204 cards installed.

Investigation

- The VFC cards were built when the Tevatron was built ~ 1983
- Past problems pointed to high humidity as being a culprit. (50 Meg resistors)
- All of these failures happened in warm weather BUT the humidity in the buildings was low(?).

VFC Status

■ As of May 1st 2003 <u>ALL</u> VFC cards have been replaced. Additionally, design changes were made to the card cages to minimize the number of connectors thus removing another failure prone device. The EE Support Department also changed the values of the voltage divider resistors to make them less humidity and dust sensitive.

Cryogenic Wet Engines

- The cryogenics Wet Engines were overhauled during one day M&D periods and were completed during the January shutdown.
- A combination of accelerator maintenance history, and a life test, showed a MTBF of 13,000 hours for the wet engines. All should be fine until the next shutdown.

How about the bigger picture?

Given the age of many of the systems at the laboratory, obsolescence is a serious problem. We keep as many spares as possible for the systems we have and prioritize the systems that can be replaced given limited resources.

FY03 Upgrade/Rehab Items STATUS

- 1)VFC's Done
- 2) Wet engines Done
- 3) Cold Compressor Bearings No longer a dilemma!
- 4) Compressor Starters On schedule 1/3 in FY02, 1/3 in '03,
 1/3 left. Might have to defer FY'03 due to budget problems!
- 5) Failure of PEI water cooled transformers Critical supplies done, will have to spend more on this.
- <u>6) Failure of Kicker Ceramic Beam Tube</u> We have found 2 new vendors and are procuring samples. No longer a problem since we have successfully recovered tubes from old kickers.
- 7) Controls Equipment Staged replacement, Review and plan soon.

And the Future

- A Vulnerability Study was commissioned to find what items would keep us off for a <u>Three</u> month time period if they failed.
- This study generated a number of items that will require replacement based on the lack of available replacement parts. Industry no longer supports some of these.

Dec 2002 White Paper & Plan to DOE

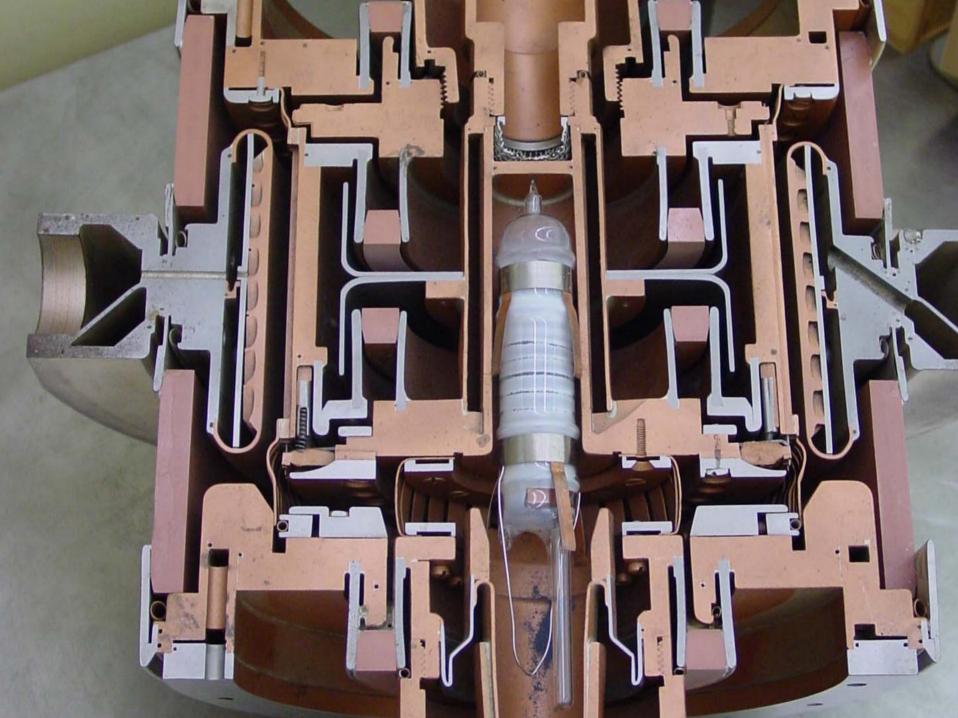
Area		Componer	Cost M&S Cont Status or Plan							
Linac	7835 Amplifier Tubes	\$1.5M	\$1.6M	60%	FY03-6					
Linac	F1123 Switch Tubes	\$200K	-	complet	ted FY03					
Linac	New Quadrupole Power Sup	plies	\$1.0M	-mainta	in existing supplies					
Linac	Water System Rebuild	\$500K	-	complet	ted FY03					
Booster Table 3.	Orbit Bump Magnets	\$1M	\$150K	40%FY	04 + labor in WBS –					
Booster	Low Level RF	\$100K	\$100K	40%	FY05					
Booster	High Power RF	\$7.5M	-		Defer					
Booster	RF Accelerating Cavities	\$10M	-		Defer					
Main Injector & Beamlines										
Dipole P	S Transformers	\$150K	\$150K	40%	FY04					
Quad PS	Transformers	\$80K	\$80K	40%	FY04					
Main Inj	ector Kicker Vacuum Tubes	\$500K	\$50K	40%	FY04 – found spares &					
vendor Engineering Support - Paul C. Czarapata										

From Plan Submitted to DOE

Tevatron Low Beta	PS Magnetics	\$30K	\$30K	40%	FY04				
Tevatron Cryogenics	Centrifugal Cold Compressors	\$100K	\$100K	40%	FY04				
Site Infrastructure	345-KV Switchgear KRS	\$200K	\$200K	20%	FY06				
Site Infrastructure	345-KV Switchgear MSS	\$300K	\$300K	20%	FY06				
Site Infrastructure	345-KV MSS Transformer	\$1.2M	-		Defer				
Site Infrastructure Other N	Filter Damping Resistors Major Majotenance Items	\$20K	\$20K	20%	FY04				
Other Major Maintenance Items									
Tevatron Replace	\$324K		40%	FY03-5					
Tevatron Correct 7	Tevatron dipole coil sag	Labor on	ıly		FY03-4				

The Most Recent Crisis

This has a wider impact than just Fermilab



Current Crisis for Four Labs

- The Burle 7835V2 is used by Argonne, Brookhaven, Fermilab, and Los Alamos
 - (and US Navy 2 sockets)
- Burle has had great difficulty in producing good tubes over the last year.
- We have managed to receive one good tube as a spare. This is after getting tubes from Argonne and Brookhaven

Why the trouble?

- Numerous retirements of key "artisans" at Burle.
- Some pressure from Military side of the house for AWACs tubes.
- Seen as a diminishing market with little return on investment.
- Captive audience! No one else makes these tubes.

What is being done?

- Working closely with the vendor to increase production.
- Working closely with the vendor to understand failures.
- Working with alternate sources for tube rebuild.
- Working with Los Alamos on alternate power system

Schedule

Gentlemen.

Thank you very much for your time last week. As discussed, we are doing everything possible to complete your 7835's as quickly as possible. The current Fermilab delivery schedule, as a result of our May 1st production meeting is as follows:

End May - 7835 New

July - 7835 New

Sept - P2R4

Oct - A30R6

Oct - N16R8

I am awaiting completion of the TC&A for AZ4R1. I believe that this device requires an anode, so it is not a quick turn-around item. I should have that TC&A, this week. I will also advise what Fermi can do to help us accelerate the delivery schedule, per our meeting.

We will contact you regarding the progress of these devices.

Please let me know if you have any questions.

Regards,

Bob Rutherford

Los Alamos Connection

- John Lyles at Los Alamos is working to build a new power station using a different tube (called a Diacrode) developed by Thales.
- New tube is a power tetrode.
- Continental Electric of Texas is interested in commercializing the power station.

Lets Talk Maintenance

- In the beginning (October of 1972 for me!) we ran until the wheels fell off then fixed them.
- Later we built in maintenance periods and often broke the machine in the process.
- Now we follow what is referred to by industry as: Reliability-Centered Maintenance.

RAC

I follow the developments in the reliability area as described by the <u>Reliability Analysis Center</u> - this is a DoD Information Analysis Center Sponsored by the Defense Technical Information Center and Operated by IIT Research Institute.

Overview of the Concept

Prior to the development of RCM, it was widely believed that everything had a "right" time for replacement or overhaul. Many maintenance personnel believed that by replacing parts of a product or overhauling the product (or reparable portions thereof), the frequency of failures during operation could be reduced."

Concept cont.

Despite this commonly accepted view, the results seemed to tell a different story. In far too many instances, PM seemed to have <u>no beneficial</u> <u>effects</u>. Indeed, in many cases, PM actually made things <u>worse</u> by providing more opportunity for maintenance induced failures."

What is RCM

- The objective of maintenance is to preserve and item's function(s).
- RCM focuses on the end system. (accelerator for us)
- Reliability is the basis for decisions.
 - Failure characteristics of the item in question must be understood to determine the efficacy of preventive maintenance.

RCM cont.

- RCM is driven first by safety and then economics
 - > Safety must always be preserved. When safety is not an issue, PM must be justified on economic grounds.
- RCM acknowledges design limitations.
 - > Maintenance cannot improve the inherent reliability it is dictated by design.

RCM

- RCM is a continuing process.
 - ➤ Differences between the perceived and actual design life and failure characteristics are addressed through age (or life) exploration.

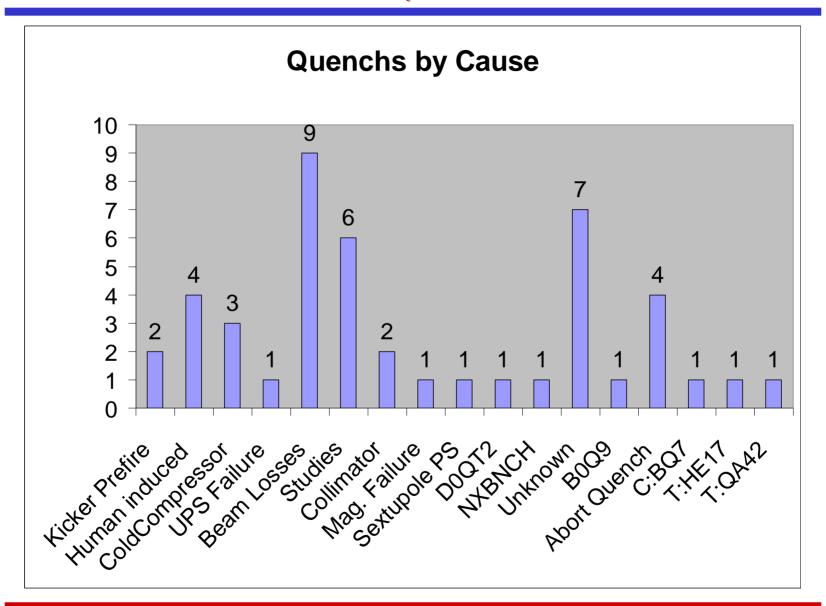
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4/26/2003 1:02 58 min. TQUEN Quench @A11U when C:BQ7 didn't ramp x 5/2/2003 19:44 2.27 hrs. TQUEN Quench during EOS studies at D48L x 5/7/2003 3:50 2.47 hrs. TQUEN F34U quench while tuning for shot setup. x 5/7/2003 8:59 1.02 hrs. TQUEN TeV quench at A48U. x 5/8/2003 23:56 1.57 hrs. TQUEN Quench DA, DB low betas; manipulating LBSEQ x 5/9/2003 22:26 4.68 hrs. TQUEN Tev quench at F3 x 5/13/2003 23:18 4.78 hrs. TQUEN Quench at F17L during scraping of Store 2542 due to T:HE17 trip. x 5/14/2003 4:44 26 min. TQUEN F1, F2, & F3 quench during QBS test. x 5/15/2003 1:15 3.62 hrs. TQUEN B0 lowbeta quench x 5/18/2003 2:25 1.28 hrs. TQUEN T:QA42 trip causing an F48L quench. x 5/19/2003 2:11 1.32 hrs. TQUEN Quench BA/BB low beat on beam abort x 5/21/2003 11:06 1.88 hrs. TQUEN Quench at F34U during Tev studies. Tev was at 150GeV. x	ŀ					1		-
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5/25/2003 18:34 50 min. TQUEN Tev quench E17U (150GeV)						X		
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6/4/2003 18:28 3.82 hrs. TQUEN Quench at B46 lower. x	٩					Х		
	L	6/4/2003 18:28	3.82 hrs.	TQUEN	Quench at B46 lower.	Х		

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2/12/2003 13:28	18 min.	TPS	T:C0SH reference stuck, Tev ramping slowed.		D0QT2		2
2/26/2003 5:50	1.03 hrs.	TPS	Injection aborts, high losses at F17 holding off studies.		C:BQ7		5
2/27/2003 16:30	1.00 hrs.	TPS	Replaced Series Shunt Module in F3 PS dump cabinet;		C:BQ9	(3
3/1/2003 16:00	191.50 hrs.	TPS	Tevatron ground fault investigation/warmup/repairs		T:HE17		4
3/10/2003 5:46	1.82 hrs.	TPS	Feeder 23 harmonic filter won't close.			1	7 47.22%
3/11/2003 18:49	2.10 hrs.	TPS	TEL modulator anode supply fan failure.				
3/12/2003 11:02	2.80 hrs.	TPS	Store lost due to B0Q5 trip. No quench.				
3/15/2003 19:48	8.00 hrs.	TPS	D0QT2 power supply tripped. PS chasis replaced.	Х			
3/16/2003 19:45	4.03 hrs.	TPS	D0QT2 investigation and PS controller chassis replacement.	Х			
4/14/2003 9:45	40 min.	TPS	T:QDE2 trip - fuse replaced				
4/14/2003 13:45	3.27 hrs.	TPS	C:B0Q9 trip on 'contactor interlock' fault - killed store 2426	Х			
4/15/2003 10:35	1.32 hrs.	TPS	C:B0QT3 power supply problems.				
4/25/2003 1:10	1.58 hrs.	TPS	T:C0SH problems - Wall breaker popped				
4/25/2003 3:30	8.27 hrs.	TPS	BQ7 tripped while ramping - antiquench indication	Х			
4/25/2003 8:00	6.48 hrs.	TPS	C:DQ0 trips when exiting the low beta squeeze (reversing switch problem)				
4/25/2003 16:15	2.83 hrs.	TPS	C:BQ7 tripped again; antiquench indication	Х			
4/26/2003 1:02	2.58 hrs.	TPS	C:BQ7 didn't ramp, causing quench	Х			
4/27/2003 12:11	5.73 hrs.	TPS	Store 2488 lost due to C:BQ7 trip.	Х			
4/28/2003 11:17	3.38 hrs.	TPS	Store lost due to C:BQ9 & C:BQ7 trip.	Х			
4/29/2003 14:27	3.50 hrs.	TPS	Store lost due to C:BQ9 trip. PLC input jumpered.	Х			
5/6/2003 15:15	2.00 hrs.	TPS	C:BQ9 trip on control fault.	Х			
5/6/2003 17:56	9.40 hrs.	TPS	C:AQ0, BQ0, CQ0 ramp problems.				
5/8/2003 9:31	43 min.	TPS	Added BQ9 diagnostics and checked B1 safety ground.	Х			
5/8/2003 10:37	40 min.	TPS	T:HE17 tripped on quench indication.	Х			
5/9/2003 4:56	27 min.	TPS	HE17 regulator changed out, was tripping on quench indication at LB.	Х			
5/14/2003 3:35	5 min.	TPS	T:VC27 fuse fault.				
5/14/2003 4:05	30 min.	TPS	T:C0SH problems.				
5/15/2003 5:45	1.68 hrs.	TPS	D2 P.S. Door indication.				
5/15/2003 8:55	56 min.	TPS	QA42 regulator changed out. Bad connector found on original regulator.				
5/15/2003 9:47	7 min.		QB15 fuse fault indication. Regulator changed out.				
5/17/2003 9:08	3.80 hrs.	TPS	T:HE17 failure/trouble shooting	Х			
5/21/2003 13:00	2.17 hrs.	TPS	T:HE17 problems and repairs.	Х			
5/31/2003 17:50	1.25 hrs.	TPS	Lead failure at B0Q2,Q3 due to multiple leads too cold. Warming up w/ squeeze				
5/31/2003 19:30	40 min.	TPS	T:F17K2 fault.				
5/31/2003 20:30	1.33 hrs.	TPS	T:QFA4 is not outputting any current.				
6/4/2003 13:50	17 min.	TPS	C:B0Q2 readback problem.				

Engineering Support - Paul C. Czarapata

February to June



The Bottom Line

- Maintenance and Infrastructure are expensive items. I have been handed a machine and supporting infrastructure that is reaching 35 years of age!
- It takes money.
- Infrastructure "bills" fall out of the sky. (HVAC in BTE/W \$640k notified 4-21-03)

Conclusion

- We take machine Reliability and Availability seriously.
- We are doing everything we can to keep the program running at the highest level of efficiency.
- We are attempting to set the proper priorities for some very expensive items.